

Case Report

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Effects of a Hardness Discrimination Task in Failed Back Surgery Syndrome with Severe Low Back Pain and Disturbed Body Image: Case study

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Abstract

A 20-year-old woman began experiencing low back pain (LBP) in September 2008 and dysesthesia, pain in the left leg, muscle weakness, and gait disturbance in January 2009. Three low back surgery were performed in April, May and July 2009, respectively. However, her symptoms were relieved for only a few days, eventually re-emerging and intensifying.

On our initial examination, on physical contact, a sharp increase in pain was experienced in the left lower back (numerical rating scale: NRS = 10). Loss of body image in the left lower back with severe pain was presented. Lying in the supine position, independent upright sitting, and trunk flexion to the left beyond a certain point were impossible.

Motor imagery and tactile discrimination training were performed. However the training was not effective. Next, the patient was asked to determine the various degrees of hardness of the sponge material that was placed on the left lower back of another person; she was simultaneously instructed to imagine it being placed on her own left lower back. Hardness discrimination training was performed for 20 min a day, 6 days a week for 4 weeks.

EEG was performed to determine the cortical activation in the somatosensory cortex during motor imagery and the hardness discrimination task.

Four weeks after hardness discrimination training, on contact with the left lower back, left LBP decreased from 10/10 to 5/10 on the subjective NRS. In addition, perception of body image in the left lower back improved. Lying in the supine position, independent upright sitting, and trunk flexion to the left became possible. Neural activity was observed in the right somatosensory cortex in the hardness discrimination task compared with the control task.

These results raised the possibility that hardness discrimination training decreased pain through reorganization of the somatosensory cortex.

Keywords: Pain; Low back pain; Failed back surgery syndrome; Body image; Discrimination; Somatosensory cortex; Electroencephalography

Introduction

Failed back surgery syndrome (FBSS) is defined as persistent chronic low back pain and/or leg pain for more than 1 year, despite treatment with 1 or more surgical procedures. Patients with FBSS often do not experience lasting relief even after administration of therapies such as repeat surgery, medication, and neuromodulation techniques. However, the effectiveness of physical therapy for FBSS has not been reported.

Extensive evidence shows that chronic back pain is associated with cortical dysfunction [1-3] and disrupted tactile processing [4,5]. In one study, disturbance in body image and decreased tactile acuity coincided with the distribution of chronic low back pain (LBP) [6]. In addition, Moseley et al. [7] demonstrated an association between neglect-like tactile dysfunction and persistent musculoskeletal disorders in patients with chronic unilateral back pain.

Complex regional pain syndrome (CRPS) can develop after tissue trauma and is accompanied with observable decreased tactile acuity [8] and altered body perception [9] as well as chronic back pain. Mosely [10] demonstrated that a motor image program comprising mental rotation, motor imagery, and mirror therapy decreased pain and disability in patients with CRPS [11]. More recently, sensory

discrimination training to the affected limb was shown to decrease pain, increase tactile acuity, and speed recovery, and might be associated with reorganization in the somatosensory cortex [12-14]. However, no studies have investigated the effectiveness of sensory discrimination training in patients with severe pain and loss of body image in the lower back.

We report the case of a patient with FBSS with severe LBP and distorted body image. Trunk movement imaging and contact with the patient's lower back was difficult. This patient was successfully treated with hardness discrimination training using sponges in contact with the lower back of another person. In addition, this study describes the result of cortical activation during the hardness discrimination task using multichannel electroencephalography (EEG).

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Case Description

Patient history

A 20-year-old woman presented with lumbar disc hernia at the L4–L5 level. The patient began experiencing LBP in September 2008 and dysesthesia, pain in the left leg, muscle weakness, and gait disturbance in January 2009. Percutaneous nucleotomy was performed from L4–L5 at another institution in April 2009 to alleviate the severe LBP and pain in the left leg. However, her symptoms were relieved for only 4 days, eventually re-emerging and intensifying. Microendoscopic discectomy (MED) and posterior lumbar interbody fusion at the L4–L5 level were performed in the same institution in May and July 2009, respectively. However, neither LBP nor leg pain was alleviated. In addition, walking became difficult 2 weeks after MED. The patient underwent implantation of a spinal cord stimulator (SCS) with bipolar leads at a different hospital in May 2011. SCS was effective in alleviating her LBP, which was indicated using a subjective numerical rating scale (NRS: unbearable pain intensity=10, 0=no pain at all). The score was reduced from 10/10 to 6/10 following SCS, but leg pain remained unaffected. Physical therapy was administered 5 days a week for 1 hour from April 2009 to December 2011. Although the physical therapy incorporated lower extremity strengthening exercises and stretching, the pain intensified. Therefore, the patient was admitted to our hospital for treatment of LBP and leg pain in January 2012.

Examinations and medication

On our initial examination, constant pain in the lower back and leg was rated 6/10 on NRS in a resting state. On physical contact, a sharp increase in pain was experienced in the left lower back (NRS=10). Analgesics including nonsteroidal anti-inflammatory drugs (NSAIDs, once daily), clonazepam (4 times daily), and tramadol hydrochloride/acetaminophen (4 times daily) were administered. The stimulation system was in continuous use 24 h/day at the following settings: amplitude 10.5 V, frequency 50 Hz, and pulse width 200.

A subjective mental representation of lower back perception was captured in a pencil drawing. Loss of body image in the left lower back with severe pain was presented (Figure 1A). The two-point discriminating threshold was not measured because her severe pain resulted in guarding. Lying in the supine position, independent upright sitting, and trunk flexion to the left beyond a certain point were impossible. Although the movement during trunk flexion to the left was very mild, the patient felt that she had reached the maximum limit.

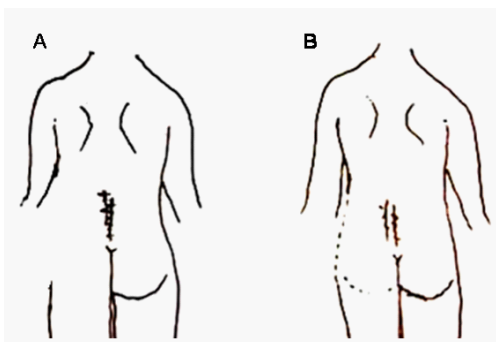


Figure 1: Body image in the lower back before (A) and after (B) hardness discrimination training.

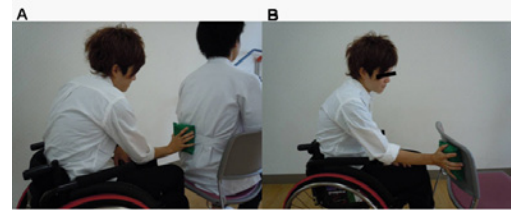


Figure 2: Hardness discrimination (A) vs. control task (B).

Rehabilitation intervention

Physical therapy was performed by three physical therapists (H.O., H.N., Y.O.). First, the patient was instructed to imagine independent trunk movement; however she was unable to do so. Second, tactile training with discrimination of the location and type of tactile stimuli was attempted in the left lower back, which was unsuccessful because of guarding. Finally, the patient was asked to lightly push on the left lower back of another person using a sponge. The patient was asked to discriminate the hardness of the sponge according to a modified version of the method described by Morioka et al. [15,16] (Figure 2A). Three sponges (INOAC Co., Aichi, Japan; 7.5×8.0×4.0 cm) with varying degrees of hardness (58.8, 78.5, and 107.9 N), which were measured by an automatic hardness tester (type JIS K6400, Asker JA, Kyoto, Japan), were used. All sponges were made of the same material and were similar in sharpness and size. The patient was asked to determine the various degrees of hardness of the sponge material that was placed on the left lower back of another person; she was simultaneously instructed to imagine her own left lower back. No pain was reported in the left lower back during this hardness discrimination task. Body perception of the left lower back returned during this hardness discrimination task. Therefore, hardness discrimination training was performed for 20 min a day, 6 days a week for 4 weeks.

EEG measurement

EEG was performed to determine the cortical activation during the hardness discrimination task while the patient was at rest in a quiet, air-conditioned room. The Discovery 24E (BrainMaster Technologies, Inc., Bedford, OH, USA) was used with 19 electrodes arranged according to the 10 to 20 international conventions with FPz as a reference. EEG signals were obtained at 256 samples/s. During measurements, the impedance of all electrodes was maintained at <5 kΩ.

Experimental task

The experiment comprised two sessions: one motor imagery task session and one hardness discrimination task session.

Motor imagery task (motor imagery vs. eyes closed)

In the motor imagery task, the patient was instructed to sit in a chair and imagine trunk flexion and extension alternately with her eyes closed. In a block design, a baseline session (30 s) was followed by motor imagery (30 s) alternating with rest (30 s), and this procedure was repeated 3 times for a total of 3 min. To differentiate from the motor imagery condition, the patient was instructed to sit in the chair with her eyes closed for 3 min.

Hardness discrimination task (hardness discrimination vs. control task)

In the hardness discrimination task, the patient was asked to

push lightly on the left lower back of another person using the sponge while discriminating its hardness. She was also instructed to imagine her own left lower back simultaneously, similar to the rehabilitation intervention (Figure 2A). To differentiate from the hardness discrimination task, the patient was asked to push lightly on the back of a chair in the control task (Figure 2B). In a block design, the baseline session (30 s) was followed by the hardness discrimination or control tasks alternating with 30 s of rest, and this procedure were repeated 3 times for a total of 3 min.

Data analysis

Both split-half and test-retest reliability tests were conducted on the edited, artifact-free, and EEG segments. Records with >90% split-half reliability, >90% test-retest reliability, and a total measurement time of >30 sec were subjected to the low-resolution electrical topographic analysis (LORETA). LORETA is a discrete, three-dimensional (3D), distributed, linear, inverse solution. LORETA inverse solution corresponds to the 3D distribution of electrical neuronal activity that features maximum similarity between neuronal populations in adjacent voxels in terms of orientation and strength.

Quantitative neuroanatomy (including Brodmann areas) was determined using the probabilistic Talairach atlas [17]. Anatomical labels such as Brodmann areas were also reported using the MNI (Montreal Neurological Institute) space, with correction to the Talairach space [18].

The removal of artifacts and calculation of the statistical properties of the segments were performed using NeuroGuide software (<http://www.appliedneuroscience.com>). Artifacts were removed using the automatic algorithms in the NeuroGuide software and by visual inspection.

To avoid multiple statistical comparisons, this study focused on one spectral band: the absolute alpha band (8–12 Hz). Alpha band activity has previously been reported to play a key role in engagement and disengagement of the somatosensory cortex depending on task demand [19]. Since most quantitative EEG norms are measured with the linked-ears montage, it was used as the standard in this study.

Statistical analysis

As stated previously, only absolute alpha values were analyzed to avoid multiple comparisons. The paired t-test was applied for data comparison using LORETA. $T > 2.1$ denoted an alpha level set at 0.05.

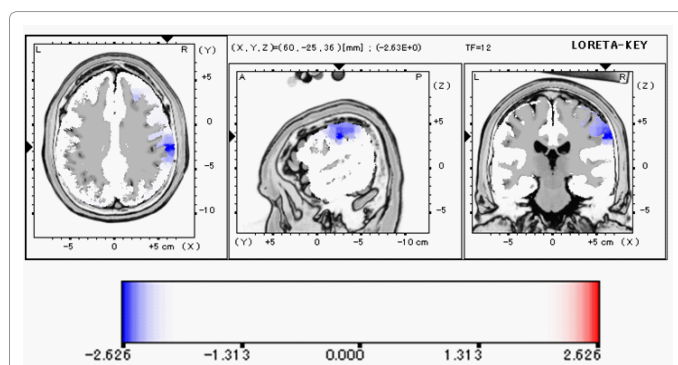


Figure 3: Differences between the hardness discrimination and control tasks based on the low-intensity electrical tomographic analysis. At cortical voxels, t values are color-coded according to the scale bar. Red and blue areas correspond to increase or decrease of alpha band activity in hardness discrimination compared to lack of discrimination, respectively.

Outcome measurement

Four weeks after hardness discrimination training, left LBP decreased from 6/10 to 4/10 on the subjective NRS in the resting state. On contact with the left lower back, left LBP decreased from 10/10 to 5/10 on the subjective NRS. Analgesics administered at this time included NSAIDs (3 times daily), clonazepam (3 times daily), opioids (3 times daily), and eperisone hydrochloride (3 times daily); SCS was gradually discontinued. In addition, perception of body image in the left lower back improved, although it remained ambiguous (Figure 1B). Lying in the supine position, independent upright sitting, and trunk flexion to the left became possible.

Eeg measurement outcome

No statistically significant differences were noted between the motor imagery and eyes closed conditions for the alpha band activity (8–12 Hz) in the right somatosensory cortex. Lower alpha band activity (12 Hz) was observed in the right somatosensory cortex (including Brodmann areas 2 and 3) in the hardness discrimination task compared with the control task (Figure 3).

Discussion

The outcome of the hardness discrimination training in the present case indicated that cortical reorganization may have been induced. As a result, pathological pain improved and severe LBP and disturbed body image were alleviated.

Severe pain, loss of body perception in the left lower back, and disability after lower back surgery have also been reported in patients with CRPS. Difficulty with anatomical identification without visual feedback has been demonstrated in CRPS patients [20]. Several studies of cortical reorganization in CRPS have noted a decrease in the cortical representation of the affected hand in the primary and secondary somatosensory cortices [21–24]. These changes support the hypothesis that body perception is distorted in patients with CRPS. Individual decrease in hand representation contralateral to the CRPS-affected limb was significantly correlated with subjective pain levels experienced over the previous 4 weeks [25]. Loss of body image in the left lower back and mismatch in flexion perception in this case may indicate a reduction in left lower back representation. In contrast, in CRPS patients who received treatment, including physical therapy and NSAIDs, significant pain alleviation was reported and cortical reorganization of the somatosensory cortex was largely reversed after approximately 1 year [26]. More recently, Benedict et al. reported that a sensorimotor retraining approach decreased pain intensity and disability in patients with chronic nonspecific LBP [27]. These studies indicate that normalization of cortical representation is required to decrease pathological pain in patients experiencing chronic pain.

Moseley et al. reported that motor imagery and a tactile discrimination task were effective in patients with LBP [10,11,13,14]. However, these tasks were ineffective in the present patient because the patient was unable to imagine trunk movement, and the tactile discrimination task induced severe pain. EEG revealed no somatosensory cortex activation during motor imagery task. The motor imagery task may have been difficult because trunk movement and related imagery had been limited for approximately two years and a half.

The hardness discrimination training task employed in this case was a modification of that described by Morioka et al. [15,16]. It involved activation of the somatosensory cortex by representation of the trunk without lower back contact. Morioka et al. demonstrated in

randomized controlled trials that plantar perceptual training using a hardness discrimination task improved stable standing posture in cerebral stroke patients and elderly people living in housing facilities [15,16]. They speculated that the hardness discrimination task resulted in an improvement in perception capability of the foot sole in their patients. In addition, active touch during surface exploration induced greater activation in the primary somatosensory cortex than passive touch [28].

In the present case, EEG confirmed a decrease in alpha band activity (12 Hz) in the right somatosensory cortex due to hardness discrimination training using sponges on the lower back of another person. This result indicated that an increase in neural activation in the somatosensory cortex was induced by this task. The somatosensory cortex is known to be responsible for body schema [29,30]. Improvement of body image perception in the left lower back during the hardness discrimination task may have occurred because of the activation of the somatosensory cortex. Reorganization of the primary somatosensory cortex in adult owl monkeys by controlled tactile stimulation and greater representation of the primary somatosensory cortex in the digits of the left hand of string players than that in controls indicated that plastic changes in the somatosensory cortex may be induced by the frequency of use [31,32]. These results raised the possibility that hardness discrimination training decreased pain through reorganization of the somatosensory cortex. In the present case, the improved body imagery through reorganization of the somatosensory cortex may have improved independent sitting upright and trunk movement to the left.

Several limitations should be considered when interpreting the results from this case report. First, and most importantly, the lack of a control group and the multiple-baseline approach may have caused changes in the outcome measures to occur spontaneously rather than as a result of the intervention. However, we believe that improvement in patients with severe pain and distorted body image over two and half years do not happen spontaneously. Second, although the hardness discrimination task resulted in substantial alleviation of symptoms and disability, it was not completely curative. During the assessment following the hardness discrimination training for 4 weeks, moderate pain and incomplete body perception persisted in the left lower back. However, the improvement achieved through the intervention was significant, quality of life was largely improved, sleep in the supine position was resumed, and independent sitting upright became possible. Finally, Hardness discrimination task was not continued because this treatment over the 4-week training period was not an effective. Moderate pain after 4-week training period might be due to injury of peripheral tissue including muscle, ligament, joint or nerve in low back than not disturbed body perception.

Conclusion

This is the first report of decreased pain and somatosensory cortex activation induced by a hardness discrimination task in a patient with distorted body image and severe LBP. These changes were associated with improved movement and alleviated disability. Future investigations will investigate the implications of these findings in a larger group of subjects with distorted body image and severe LBP.

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